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A Numerical Simulation of the Onset of El Niño

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ABSTRACT

El Niño may be defined oceanographically as a massive influx of warm water into the coastal region of Ecuador and Peru. We have tested the hypothesis that these rare events occur after a substantial reduction of the atmospheric trade winds over the central Pacific Ocean. An idealized nonlinear, two-layer, equatorial beta-plane ocean is spun-up with easterly winds for 50 days after which the wind is relaxed over several days. The relaxation of the wind initiates internal Kelvin wave fronts at both sides of the ocean at the equator. The eastern wave fronts propagate poleward and the western ones eastward. Internal Rossby waves are generated which propagate westward from the eastern boundary. As the Kelvin wave fronts move poleward along the eastern boundary, strong downwelling occurs and the coastal currents reverse direction and become poleward. The rapid downwelling and the sudden reversal of the coastal current are consistent with observations during El Niño. This downwelling is much more rapid than the upwelling which occurred during spin-up due to nonlinear Kelvin wave dispersion. The dispersion results in the development of a frontal character at the leading edge of the waves. When the western Kelvin wave fronts reach the eastern boundary, the downwelling ceases and the poleward currents separate from the coast, propagating westward as Rossby waves. Thus we suggest the pulsating nature of El Niño is related to the occurrence of major equatorial wind changes and the dynamics of internal Kelvin waves whose nonlinear attributes may greatly sharpen the pulses.

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